

Appl. No. 10/688,589
Amdt. Dated 29 July 2005
Reply to Office action of 18 July 2005

REMARKS

Reexamination and reconsideration of this application as amended is requested. By this amendment, claims 1, 15, and 28 have been amended. Claims 1-29 remain in the application.

CLAIM REJECTIONS UNDER 35 U.S.C. §102

Claims 1-16 and 18-29 have been rejected under 35 U.S.C. 102(b) as being anticipated by La Fontaine et al. U.S. Patent No. 6,645,679, hereinafter referred to as La Fontaine. The Examiner in making this rejection states that La Fontaine teaches the Applicants' claimed invention directed to an extreme ultraviolet (EUV) lithographic mask and method of forming the mask for reflecting radiation having a wavelength of less than 40 nanometers. The Applicants respectfully traverse this rejection and assert that La Fontaine does not anticipate the Applicants' claimed invention.

The Applicants assert that La Fontaine describes and claims an attenuated phase shift mask that includes a multilayer film having locally modified portions to achieve attenuating and phase shifting and reflection. The mask achieves both attenuating and phase shifting as well as reflection on the same surface of the multilayer film, wherein the layers in each are formed of the same material, having portions modified to achieve the attenuating and phase shifting, and reflectance. As illustrated in La Fontaine, a multilayer film having a single planar surface is provided having heat treated portions to achieve desired attenuating and phase shifting.

FIG. 10 of La Fontaine includes a central part 120 of the mask, and illustrates a collapse, and resultant depression, of multilayer stack 14 in areas that received heat treatment. This depression within the multilayer stack results in a region of low reflectance and phase shift compared with nearby

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high reflectance regions. In more detail, the local modification of Mo/Si multilayer mirror 14 by heat treatment (laser or electron beam) results in damage to the multilayers, thus reducing the reflectance. The damage, in the form of depressions in the surface of the uppermost multilayers causes a phase shift by the depression gap. The Applicants assert that while this structure is conceptually feasible, the two areas of optical interests are difficult to clearly define because the heat treatment is the agent for the pattern definition. In FIG. 10 the illustrated curved depression indicates this effect and the blurred boundary from a top view would result in low resolution imaging on the wafer.

The Applicants assert in contrast to La Fontaine, the Applicants device as claimed includes a substrate; a first reflectance region overlying said substrate; and an attenuating phase shifter overlying said first reflectance region and comprised of a first layer, and a second layer having a second reflectance region formed therebetween. The Applicants have claimed that the attenuating phase shifter as overlying the first reflectance region. In addition, the Applicants have claimed within the attenuation phase shifter, the inclusion of a second reflectance region that is positioned overlying the first reflectance region. More specifically, the Applicants assert that the attenuating phase shifter of the Applicants' claimed device as overlying the first reflectance region and comprised of a first layer, and a second layer having the second reflectance region formed therebetween. The first layer of the attenuating phase shifter is claimed as having a thickness selected to alter the phase relationship between the first reflectance region and the second reflectance region, resulting in destructive interference between reflections from the first reflectance region and the second reflectance region. The Applicants have claimed separate and distinct layers forming the first reflectance region and the second reflectance region formed as part of the attenuating phase shifter.

Rather than local modification of the multilayer mirror structure as in La Fontaine for required attenuation and phase shift, the Applicant's multilayer mirror structure itself is designed for specific

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amount of attenuation and phase shift by embedding an extra layer, other than Mo and Si, inside the multilayer mirror (i.e. Mo/Si film stack) structure. The Applicants' invention does not require a local heat treatment using a heat mask as in La Fontaine. As shown in FIGs. 6 and 7 of the Applicants' disclosure, a foreign layer 603 is embedded at controlled position inside the Mo/Si multilayer stack (604 and 602), so that an attenuated phase shift mask can be fabricated by etching multilayer up to that specific embedded layer which is functioning as an etch stop layer during fabrication. The amount of attenuation and phase shift of the mask is predetermined by the controlled position inside the multilayer and thickness of the embedded layer rather than the amount of heat damage on the region as in La Fontaine. The Applicants provide an attenuated phase shift mask for EUV that is made from a predesigned multilayer and patterning of the multilayer into two distinct and separate film stacks.

The Applicants' layers 303, 304 and 305, illustrated in FIG. 1, provide attenuation by destructive interference of the radiation incident on region 305 with the radiation reflected from region 306. The destructive interference used for attenuated phase shift masks is between radiation reflected from region 305 and region 306, illustrated in Figure 1.

As previously stated, the Applicants embedded layer 303 has a key role in satisfying phase shift and attenuation requirements. The Applicants embedded layer 303 is located between identical multilayer structures, upper 304 and bottom 302, the constructive or destructive interference effects are heavily dependent on the thickness of the embedded layer 303. La Fontaine fails to include two distinctly different multilayer structures separated by an embedded layer, and rather heat treats a portion of the single multilayer structure to create the modified portions. The Applicants' destructive interference is occurring inside the patterned stack 303, 304 and 305 that is separate from multilayer reflectance region 302.

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The Applicants have amended claims 1, 15 and 28 to each include an instance of the word —second— where it was mistakenly believed to have been omitted. The term —second reflectance region— was previously used throughout the claims. Accordingly, no new matter has been presented by the amendments.

The Applicants believe that the claims as previously presented are not anticipated by La Fontaine. Accordingly, the Applicants believe that claims 1, 15 and 28 are in a condition for allowance. The Applicants additionally believe claims 2-14, 16, 18-27, and 29 are also allowable since they depend from what is believed to be an allowable claim and for the limitations they add to the above mentioned features. Accordingly, it is believed that the rejection of claims 1-16 and 18-29 under 35 U.S.C. 102 have been overcome by the remarks.

CLAIM REJECTIONS UNDER 35 U.S.C. §103

Claims 1-29 have also been rejected under 35 U.S.C. 103(a) as being unpatentable over La Fontaine. The Examiner in making this rejection states that La Fontaine essentially teaches the claimed invention as detailed. The Examiner further states that the teaching of La Fontaine differs from those of the Applicant in that the Applicant teaches the use of a 27 Angstroms thick layer of NiFe in the attenuating phase shifting layer. The Examiner asserts that it would be expected that any material which has the required optical properties with respect to attenuation and phase shifting could be used in the mask. Therefore, the Examiner asserts that it would have been obvious to one having ordinary skill in the art to take the teachings of La Fontaine and incorporate the use of a NiFe layer in order to make the claimed invention because one would know to use any material that had the required optical

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properties with respect to attenuation and phase shifting. The Applicants respectfully traverse this rejection and state that La Fontaine does not make obvious the Applicants' claimed invention.

The Applicants assert that La Fontaine describes and claims an attenuated phase shift mask that includes a multilayer film having locally modified portions to achieve attenuating and phase shifting, and reflection. The mask achieves both attenuating and phase shifting as well as reflection on the same surface of the multilayer film structure, wherein the layers in each are formed of the same material, having portions modified to achieve the attenuating and phase shifting, and reflectance. As illustrated in La Fontaine, a multilayer film structure having a single planar surface is provided having heat treated portions to achieve desired attenuating and phase shifting.

As previously stated, in La Fontaine the local modification of Mo/Si multilayer mirror 14 by heat treatment (laser or electron beam) results in damage to the multilayers, thus reducing the reflectance. The damage, in the form of depressions in the surface of the uppermost multilayers causes a phase shift by the depression gap.

The Applicants assert in contrast to La Fontaine, the Applicants' device as claimed includes a substrate; a first reflectance region overlying said substrate; and an attenuating phase shifter overlying said first reflectance region and comprised of a first layer, and a second layer having a second reflectance region formed therebetween. The Applicants have claimed that the attenuating phase shifter as overlying the first reflectance region. In addition, the Applicants have claimed within the attenuation phase shifter, the inclusion of a second reflectance region that is positioned overlying the first reflectance region. More specifically, the Applicants assert that the attenuating phase shifter of the Applicants' claimed device as overlying the first reflectance region and comprised of a first layer, and a second layer having the second reflectance region formed therebetween. The first layer of the

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attenuating phase shifter is claimed as having a thickness selected to alter the phase relationship between the first reflectance region and the second reflectance region, resulting in destructive interference between reflections from the first reflectance region and the second reflectance region. The Applicants have claimed separate and distinct layers forming the first reflectance region and the second reflectance region, that are separated by the embedded layer.

As previously detailed, the Applicant's multilayer mirror structure is designed for specific amount of attenuation and phase shift by embedding the extra layer, preferably formed of NiFe, inside the multilayer mirror (i.e. Mo/Si film stack) structure. The Applicants' invention does not require a local heat treatment using heat mask. The amount of attenuation and phase shift of the mask is predetermined by the controlled position inside the multilayer and thickness of the embedded layer rather than the amount of heat damage on the region as in La Fontaine.

As previously stated, the Applicants embedded layer 303 has a key role in satisfying phase shift and attenuation requirements. La Fontaine fails to include in essence two multilayer structures separated by an embedded layer, and rather heat treats portions of the single multilayer structure to create the modified portions. The Applicants' destructive interference is occurring inside the patterned stack 603, 604 and 605 that is separate from multilayer reflectance region 602. Accordingly, the applicants assert that a mere incorporation of the use of a NiFe layer into the device of La Fontaine, fails to make obvious the Applicants' claimed invention.

The Applicants believe that the claims as previously presented are not obvious in light of the teachings of La Fontaine. Accordingly, the Applicants believe that claims 1, 15 and 28 are in a condition for allowance. The Applicants additionally believe claims 2-14, 16-27, and 29 are also allowable since they depend from what is believed to be an allowable claim and for the limitations they

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add to the above mentioned features. Accordingly, it is believed that the rejection of claims 1-29 under 35 U.S.C. 103 has been overcome by the remarks.

CONCLUSION

No amendment made herein was related to the statutory requirements of patentability unless expressly stated; and no amendment made herein was for the purpose of narrowing the scope of any claim, unless Applicant has argued herein that such amendment was made to distinguish over a particular reference or combination of references.

Accordingly, Applicants respectfully submit that the application, as amended, is now in condition for allowance, and such allowance is therefore earnestly requested. Should the Examiner have any questions or wish to further discuss this application, Applicants request that the Examiner contact the Applicants attorneys at 480-385-5060.

If for some reason Applicants have not requested a sufficient extension and/or have not paid a sufficient fee for this response and/or for the extension necessary to prevent abandonment on this application, please consider this as a request for an extension for the required time period and/or authorization to charge Deposit Account No. 50-2091 for any fee which may be due.

Respectfully submitted,
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